METHOD AND APPARATUS FOR COMPUTERIZED RECOGNITION

REFERENCE TO RELATED APPLICATIONS

This application is a continuation of a co-pending application Ser. No. 08/001,123, filed Jan. 5, 1993 which in turn is a continuation-in-part of application Ser. No. 07/889,216, filed May 27, 1992, now abandoned, and both of which are assigned to the assignee of the present application, and both of which are hereby incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

This invention relates generally to handwriting recognition, and more particularly to handwriting recognition in a pen-based computer system.

A pen-based computer system typically comprises a small, hand-held computer where the primary method for inputting data includes a "pen" or stylus which "writes" upon the screen of the computer system. The screen is a dual-function display assembly which serves as both an input device and an output device. When operating as an input device, the display assembly senses the position of the tip of a stylus on the viewing screen and provides this positional information to the computer's central processing unit (CPU). Some display assemblies can also sense the pressure of the stylus on the screen to provide further information to the CPU. When operating as an output device, the display assembly presents computer-generated images on the screen.

The dual-function display assemblies of pen-based computer systems permit users to operate the computer as a computerized notepad. For example, graphical images can be input into the pen-based computer by merely moving the stylus on the surface of the screen. As the CPU senses the position and movement of the stylus, it generates a corresponding image on the screen to create the illusion that the stylus is drawing the image directly upon the screen, i.e. that the stylus is "inking" an image on the screen. Besides serving as a notepad, pen-based computers can provide a number of useful functions, such as serving as an address book, an appointment calendar, a to-do list, etc.

Ink on the screen of a pen-based computer system is typically stored as a simple bit-map. Essentially, the only knowledge that the computer system has of the inked image is that certain pixels of the display are to be activated to create the inked image. Therefore a note, such as "Meet Bob Tuesday" has no meaning to the system other than certain pixels of the screen are to be turned on or off to create the inked image of the words.

It is often desirable to perform some level of recognition on the inked objects formed on the computer screen. In this way, additional meaning can be attached to the inked objects allowing the computer to manipulate the objects in a more intelligent fashion. For example, a common recognition for pen-based computer systems is handwriting recognition. In this way, the inked object "Meet Bob Tuesday" can be "recognized" as comprising three words separated by spaces where each word comprises a number of letters. The recognized words and letters can be convened into an appealing font, and can be used and manipulated as words and letters rather than as bits in a bit-map.

There are a great many methods for recognizing handwriting known in the prior art. However, these recognition methods tend to be narrowly focused on a particular type of

recognition task. For example, there are prior art recognizers for recognizing alphanumeric inputs, for recognizing graphical inputs, etc. If a recognizer of the prior art does not recognize a particular type of object that object is typically treated as ink.

This form of limited recognition imposes certain restraints on a pen-based computer system. For example, some prior art pen-based computer systems require that alphanumeric data be written in specific, defined locations or "fields" on the screen. Alphanumeric information not written in those fields may not be recognized, and non-alphanumeric information written within the fields will not be recognized. This limits the pen-based computer system to essentially serving as a computerized entry form rather than a free-form notepad.

SUMMARY OF THE INVENTION

The present invention performs a recognition task on strokes that are entered into a pen-based computer system in an unstructured or flee-form fashion. The system uses a number of recognition domains, each of which is designed to recognize a certain type of object and to provide an interpretation of that object's meaning. In the event that them are multiple interpretations for a particular inked object or stroke, the system will perform an arbitration function to determine a "best guess."

A recognition system for a pen-based computer system in accordance with the present invention includes a tablet for inputting strokes made by a stylus; a low-level recognizer responsive to the strokes and operative to perform low-level recognition on the strokes; a high-level recognizer responsive to at least some of the strokes and operative to perform high-level recognition on at least some of the strokes; and a recognition interface permitting communication between the recognizers and an application program. The low-level recognizer can, for example, recognize strokes having special meanings known as "gestures." For example, a special gesture can be provided to select certain portions of the computer screen, or to provide a "breaker bar" between adjacent notes. The high-level recognizer, on the other hand, recognizes higher level meanings from strokes, such as characters and words in English and other languages, simple geometric shapes such as triangles and squares, etc. The interface can pass recognized objects to the application program, and can receive back objects that have been rejected by the application program.

A high-level recognition system in accordance with the present invention includes a controller capable of receiving units to be recognized; a number of recognition domains coupled to the controller where each of the recognition domains can receive one or more units from the controller and is capable of providing an interpretation of the one or more received units to the controller; and an arbiter coupled to the controller which is capable of resolving conflicts between multiple interpretations developed by the recognition domains. The controller is preferably responsive to stroke units generated by a stylus on the screen of a pen-based computer system, but may also be responsive to units provided by other types of input devices (e.g., voice recognition units). The controller is also preferably coupled to a number of recognition areas and to a recognition database. The recognition domains are each designed to recognize a particular type of object, e.g., there can be a recognition domain to recognize letters, words, kanji characters, numbers, formulas, simple geometric shapes, etc. If